POSITION OF METEOROLOGY AMONG THE SCIENCES.

By CHARLES F. VON HERRMAN.

[Author's abstract.]

This paper begins with a critical study of the criteria of Comte, Bacon, Pearson, and Spencer in the classification of the sciences, with the object of discussing the position of each one of these scientists with reference to meteorology.

Pearson places meteorology among the sciences purely descriptive. Perhaps he is right. Meteorology is yet an imperfect science, because its phenomena are extremely complex, subject to the influence of innumerable factors. Physics and astronomy also passed through an epoch of imperfection. Even to-day they are imperfect in the analysis of problems of great difficulty; but day by day they were perfected up to the point in which it was possible to formulate their data mathematically. On account of the nature of things it is not possible to have an absolutely exact science, and much less can there be exactness in meteorology. While astronomic phenomena, for example, depend upon the universal law of gravitation only, meteorological phenomena are subject to solar radiation, to the influence of heat on the air and the vapor which it contains, and the configuration of the earth and its rotation. Systematic progress in the field of meteorology is therefore very difficult, as has been the case with chemistry and physics which are based on experimentation; because this experimentation, besides being extremely difficult, attempts to determine laws of the phenomena of the whole planet. But in spite of this complexity it has been possible in recent years to formulate the mathematical laws by which meteorological phenomena are controlled. These have such a firm basis that meteorology has now acquired a high place in the classification of natural sciences.

Meteorology is divided, like astronomy, into static and dynamic: Climatology and dynamic meteorology. Climatology is descriptive and its study has to do with the average condition of the atmosphere in different places, especially in its relation to organic life. Dynamic meteorology is the more important division of the science, and the study of its phenomena is extremely complicated, requiring a consideration of the pressure, temperature, and movement of the air. The study of its phenomena requires the solution of problems of physics and mathematics of the greatest difficulty.

The progress of the mathematical study of meteorology has been along two lines: One leads to the theory of cyclonic movements and the other to the discussion of the thermodynamic principles related to the condensation of humidity in clouds and rain and to the changes of temperature dependent upon the expansion and contraction of the air. The author analyzes some of the works and mentions others which mark the progress of the science of meteorology, as those of Ferrel, Mohn, Overbeck, Espy, Bigelow, Margules, etc.

The paper concludes with a classification of the sciences according to Pearson, based on the "mutual relation of the sciences and their continuous development."

THE FERREL DOCTRINE OF POLAR CALMS AND ITS DISPROOF IN RECENT OBSERVATIONS.

By WILLIAM H. HOBBS.

[Author's abstract.]

The theory of William Ferrel that the poles of the earth are surrounded by areas of calm, surrounding which is a whirl of persistent westerly winds, was promulgated as a part of a larger scheme of atmospheric circulation and at a time when meteorological observations had not been carried far into the polar regions. Objections to the theory were found so soon as successful explorations had been pushed southward beyond the Antarctic Circle; but the anticyclonic conditions which were there encountered and found to be in conflict with the Ferrel theory were explained as due to their position near the geographic pole.

In the years 1910 and 1911 the writer pointed out, upon the basis of the scientific data then available from the Antarctic regions, that the control of atmospheric circulation is there determined not by latitude, but by the vast blanketing dome of ice (the continental glacier) enwrapping the continent. This cold snow-ice mass causes fierce storms and prolonged calms to alternate above it in strophic succession; and the storms being directed outward, or radially, draw down with the air from the upper levels the ice needles that make up the cirrus and cirroid clouds. During their descent these ice needles are first melted and later evaporated, but when the resultant vapor approaches the cold ice surface it is precipitated out again as snow or as fine ice needles.

The surface system of winds above a continental glacier being thus found to be centrifugal, the slopes of the glaciers are visited by blizzards fiercer than any known elsewhere, while the central areas are characterized by variable light winds, by much vapor content, and by frequent falls of fine ice needles often while the sun is shining. It is proper, therefore, to regard the vast continental glacier of the Antarctic, and in less degree that which lies on the Greenland Continent, as the poles, respectively, south and north, in the atmospheric circulation. It is at these poles that the high level poleward currents of air and the moisture which has been locked up in the cirri are in large part returned to the circulation at the surface levels and directed equatorward.

Since this theory was first promulgated in the year 1910 the southern geographic pole has been twice attained, and several crossings of the ice upon the Greenland Continent have been carried out. The meteorological data from these expeditions have confirmed in a convincing manner all the essential attributes of the glacial anticyclones.

WIND VELOCITY AND ELEVATIONS.

By W. J. HUMPHREYS.

[Author's abstract.]

Everyone knows, from mere casual observations of tree tops and such floating objects as clouds, leaves, and dust, that wind velocity increases with elevation. Careful measurements show: (*a*) That it is quite rapid through the first few hundred meters, the region of surface disturbance; (*b*) that through the next layer, roughly 500 to 1,500 meters, it is comparatively slow and irregular; (*c*) that from about 1,500 meters elevation to the isothermal level it is approximately uniform and moderately rapid; and (*d*) that above the isothermal level it generally has a negative value.

From 4 or 5 to 10 or 11 kilometers elevation the velocity of the wind increases at approximately the same rate that its density decreases. Hence, between these levels the product of velocity by density remains roughly constant, a law first formulated by Axel Egnell.

These important relations of wind velocity to altitude depend essentially upon two factors, temperature distribution and earth rotation, from which they logically may be deduced by the aid of a few suitable equations.

SOLAR ACTIVITY, CYCLONIC STORMS, AND CLIMATIC CHANGES.

By ELLSWORTH HUNTINGTON.

In recent publications the author has advanced the hypothesis that climatic variations, both of the present and the past, may be due in large measure to variations in the intensity and locations of the belts of cyclonic storms, and that these in turn may be due to variations in solar activity. The basis of the hypothesis is the observed fact that when sun spots are numerous and the sun gives out more heat than usual, the earth's surface is abnormally cool and the number of cyclonic storms and the general intensity of the atmospheric circulation are above the average. The sun's activity, whether by means of greater heat or greater electrical radiation, appears to cause more cyclonic storms. In the centers of such storms there is an upflow of warm air. Increased storminess must carry much warm air into the upper layers of the atmosphere, and thus cool the lower layers.

Examination of charts of storminess in North American and Eurasia shows that on both continents there is a tendency toward the development of a subtropical storm belt, as well as of the usually recognized boreal belt. The evidence of the subtropical belt is found in areas of increased storminess in Kansas and east of the Appalachians in the United States, and in closely similar but much more pronounced centers of storminess in northern Italy and Japan in Eurasia.

At times of many sun spots the two belts tend to become more distinctly separated, while the component parts of the subtropical belt tend to coalesce into a single belt in each continent, as is shown by the records of the past 30 or 40 years. Each belt tends to be shoved outward from the center of the continent, so that storminess there decreases, while on the periphery it increases. The increased storminess of the main northern belt continues through a large part of the year. In the subtropical belt, however, the increase in the number of storms occurs chiefly at the beginning of winter and in the late spring; that is, at the beginning and end of the rainy period in countries where the Mediterranean type of rainfall prevails.

In the past there appears to have been a period of exceptional climatic stress, culminating in the fourteenth century. Evidence of this is derived (1) from the expansion of lakes in western and central Asia, (2) the growth of trees and the expansion of lakes in the similar climatic area of the United States, (3) intense cold, excessive storminess, and consequent economic distress in Scandinavia and around the North Sea, and (4) an increase of ice, together with other disasters, such as the failure of crops, in Greenland. The places from which the evidence is derived are located in the regions where storminess now increases at times of many sun spots. Although data are scarce, there is some indication that the fourteenth century was a time of unusual sun-spot activity. The final conclusion seems to be that changes in solar activity are a chief cause of present climatic fluctuations and also of the much larger climatic changes that have taken place in the past.